



DEAKIN MEDICAL SCHOOL

HME922

BRAIN AND BEHAVIOUR

BB2

Brainstem and Cranial nerves

2020 STUDENT

Workshop notes and activities

KEY STAFF**Topic Coordinators**

Laura Gray & Jacinta Crawley

l.gray@deakin.edu.auj.crawley@deakin.edu.au**Anatomy teaching staff**

Kylie Pickles

k.pickles@deakin.edu.au

Cailin Mellberg

cailin.mellburg@deakin.edu.au

Aidan Roberts

aidan.r@deakin.edu.au

Chris Briggs

chris.briggs@deakin.edu.au

Sophie Tobias

sophie.tobias@deakin.edu.au**Pathology**

Melanie Sullivan-Gunn

melanie.gunn@deakin.edu.au

Malik Mahmood

malik.mahmood@deakin.edu.au

Heather Morrison

h.morrison@deakin.edu.au**Demonstrating Staff**

Matthew Retallack

Andrea O'Hoy

Jacinta Crawley

Amy Chan

Technical Staff

Alana Neale

Organisation of Workshops

These sessions will be delivered in an online format providing opportunity for students to develop their understanding of neuroanatomy and its clinical applications. Learning resources and activities will be available to augment the workshop notes and the professional demonstrating team will be available to work with students to clarify content and understanding. Each workshop session will be accessible for three hours and include both large and small group learning opportunities.

It is highly recommended that you read through these notes prior to the workshop and use the material as a guide for consolidating your understanding of the topic each week. This will enable you to identify any aspects that are not clear to you and give you the opportunity to focus on these during the workshop.

Expectations for online workshops

Instead of the usual PPE, it is expected that students will be able to log in to their allocated workshop room and ensure that their microphone is functioning so that they can contribute to the session. Professional etiquette is expected and ensuring a friendly and safe environment for learning is essential to encourage participation and enjoyment for all.

Anatomy & Pathology museum: Recommended learning resources:

To enhance your understanding of the anatomy of the head, recommended resources are available through the Anatomy and Pathology museum site. This is additional to the material you have covered in your lectures and workshops and is recommended as a resource to clarify any particular areas you may feel necessary.

<https://wiki.deakin.edu.au/display/PathologyMuseum/>

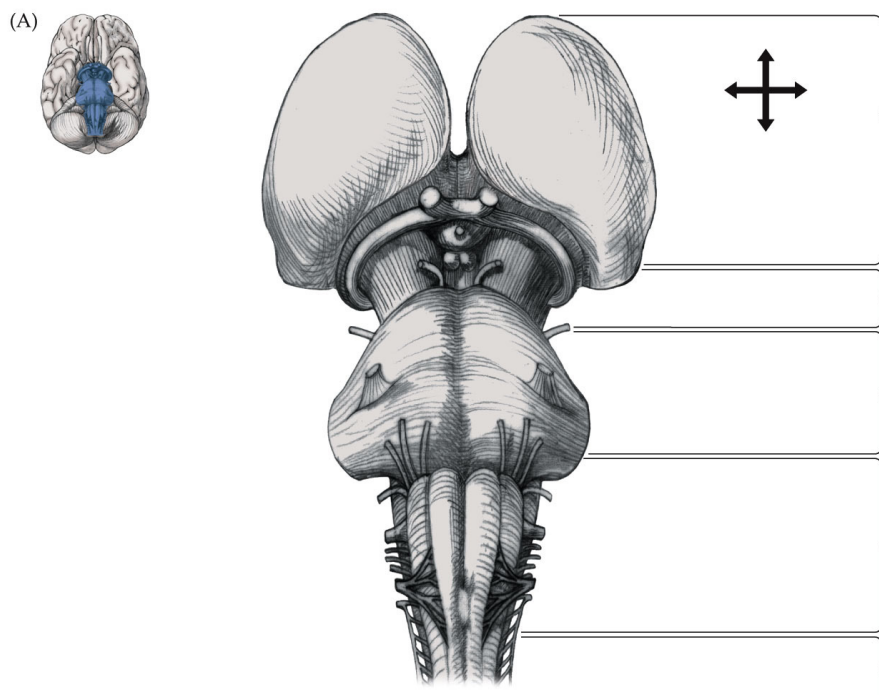
STATION 1. ANATOMY OF THE BRAINSTEM

The brainstem consists of three anatomical areas; the midbrain, pons and medulla oblongata. The cerebellum is attached to the dorsal surface of the pons and upper medulla. The brainstem contains many ascending and descending nerve fibres. Interspersed among these are numerous aggregations of cell bodies (nuclei), many of which have vital functions. These include the regulation of conscious state, muscle tone and posture, and the control of cardiac function and respiration.

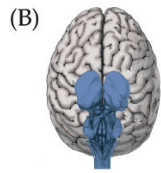
The cell bodies of the majority of cranial nerves (III to XII) are also located in nuclei in the brainstem. Collectively cranial nerves provide both sensory and motor innervation for the head and neck. This includes general and special sensation as well as voluntary and involuntary muscle control. Individual cranial nerves may be purely sensory, purely motor or mixed.

On the following illustrations identify the following:

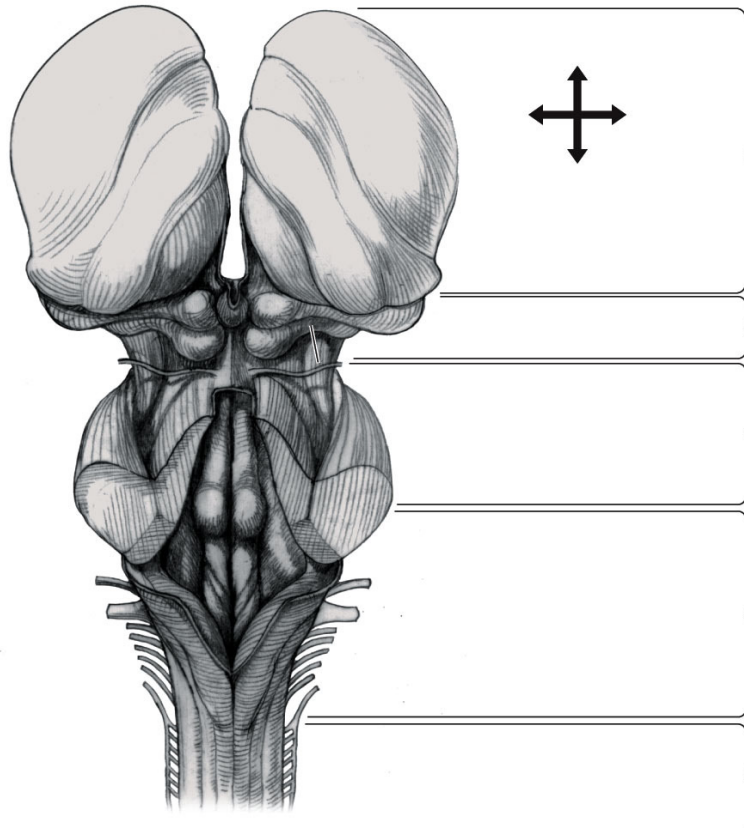
- Superior, inferior, left, right
- Thalamus, midbrain, pons, medulla, spinal cord
- Cranial nerves: III, IV, V, VI, VII, VIII, IX, X, XI, XII



VENTRAL ASPECT

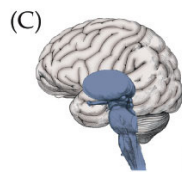


DORSAL ASPECT

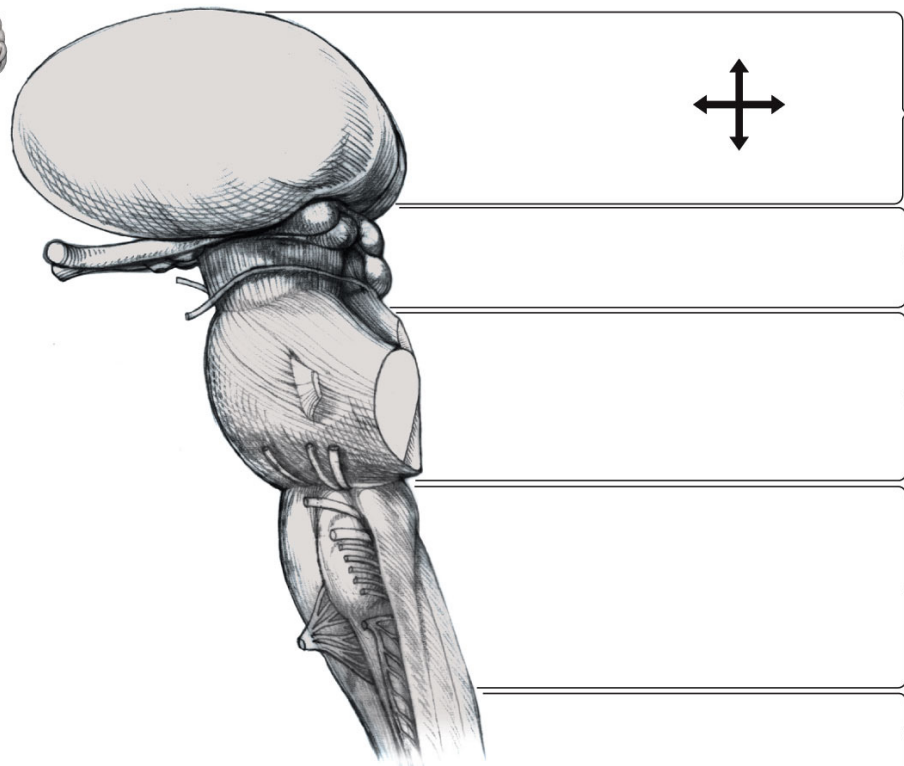


NEUROANATOMY 2e, Figure 12.2 (Part 2)

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LEFT LATERAL ASPECT



NEUROANATOMY 2e, Figure 12.2 (Part 3)

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On a photographic image provided, identify the three regions of the brainstem and the cranial nerves exiting from each.

Region	Cranial nerves exiting
Midbrain	
Pons	
Medulla	

Which cranial nerve is the only one to leave from the dorsal aspect of the brainstem?

MIDBRAIN

The midbrain connects the thalamus and hypothalamus to the pons. The superior and inferior colliculi on the dorsal surface form the roof (tectum) of the midbrain. The ventral surface is formed by the cerebral peduncles containing the descending fibres of the corticospinal tract. Internally the cerebral aqueduct (of Sylvius) passes through the midbrain and the nuclei of cranial nerves III (oculomotor) and IV (trochlear) are located. The distinct formations of the substantia nigra and red nuclei are also clearly visible in an axial section of the midbrain.

Return to the illustrations above and identify the following structures of the midbrain. Record their functions below and then identify their location on the images provided in the workshop.

MIDBRAIN FEATURES	FUNCTION
<u>DORSAL</u>	
Superior & inferior colliculi (Tectum)	
Trochlear nerve	

<u>VENTRAL SURFACE</u>	
Cerebral peduncles	
Oculomotor nerve (III)	
<u>AXIAL SECTION</u> (through superior colliculus)	
Cerebral aqueduct	
Nuclei of CN III	
Substantia nigra	Forms part of basal ganglia pathway and has an important role in motor control. (will be discussed in week 4)
Red nucleus	The red nucleus is involved in motor control and is linked with the cerebellum and rubrospinal tract. (discussed in week 4)

Transverse section through the caudal midbrain at the level of the inferior colliculus.



Fig. 9.13

Transverse section through the rostral midbrain at the level of the superior colliculus.

<https://www-clinicalkey-com-au.ezproxy-b.deakin.edu.au/#!/content/book/3-s2.0-B978070207462200009X?scrollTo=%23h10000304>

Which cranial nerves have their nuclei in the midbrain?

Which reflex can be used to help assess the function of the midbrain?

PONS

The pons (Latin: bridge) is best seen from the ventral surface of the brainstem as an expanded structure between the midbrain and medulla oblongata. The dorsal surface of the pons is concealed by the cerebellum which is attached to the pons by the cerebellar peduncles. The cerebral aqueduct opens into the fourth ventricle at the upper border of the pons. Cranial Nerve V (trigeminal) emerges from the ventrolateral aspect of the pons with a large sensory and small motor root. Internally, the pons contains the motor and sensory nuclei of the trigeminal nerve and the nuclei of CNVI, VII & VIII plus the salivary nuclei (parasympathetic).

Return to the illustrations above and identify the following structures of the midbrain. Record their functions below and then identify their location on the images provided.

PONS FEATURES:	FUNCTIONS
<u>VENTRAL SURFACE</u>	
Trigeminal nerve (V)	
Abducens nerve (VI)	
Facial nerve (VII)	
Vestibulocochlear nerve (VIII)	
<u>DORSAL SURFACE</u>	
Cerebellar peduncles – superior, middle, inferior	Connect cerebellum to brainstem bilaterally
4 th ventricle (upper part)	Part of ventricular system and CSF flow throughout CNS (covered in BB5)
<u>AXIAL SECTION</u>	
Cerebellar peduncles	Connect pons to cerebellum bilaterally
Basis pontis	Contains descending corticospinal and corticobulbar tracks and nuclei associated with cerebellar function.
4 th Ventricle	Part of ventricular system and CSF flow throughout CNS

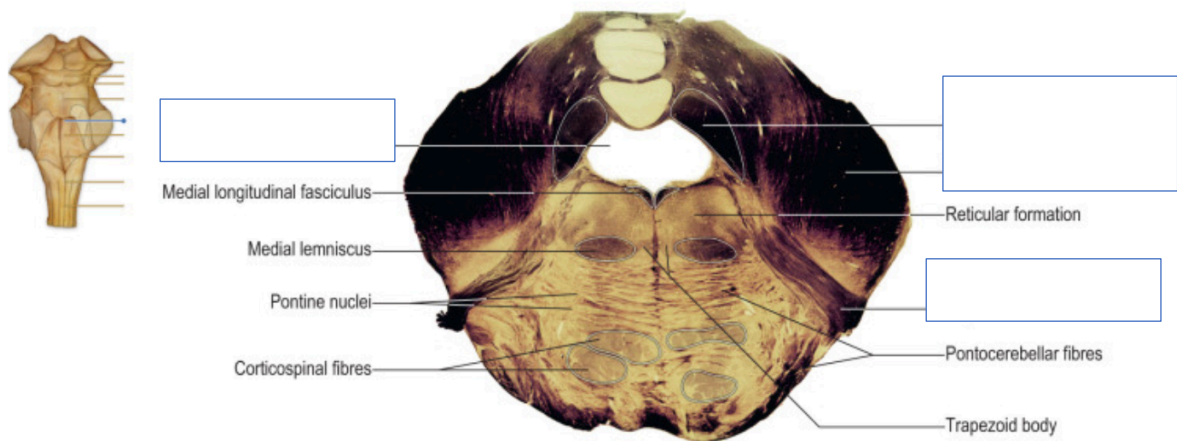


Fig. 9.9

Transverse section through the mid-pons at the level of the trigeminal nerve.

MEDULLA

The medulla oblongata is immediately rostral to the spinal cord. On either side of the ventral surface are prominent bulges formed by the pyramids. These contain the descending fibres of the important corticospinal (pyramidal) tract. In the 'decussation', 85% of the fibres in each corticospinal tract will cross to the contralateral side to form the lateral corticospinal tract of the spinal cord. Cranial nerves IX- XII emerge from the ventral surface.

The upper part of the dorsal surface is taken up by the lower part of the fourth ventricle. Below the 4th ventricle, the gracile and cuneate nuclei are located at the rostral end of the fasciculus gracilis and fasciculus cuneatus respectively.

Return to the illustrations above and identify the following structures of the midbrain. Record their Functions below and then identify their location on the images provided.

MEDULLA FEATURES:	FUNCTIONS
<u>VENTRAL SURFACE</u>	
Pyramids	
Olive	
Glossopharyngeal nerve (IX)	
Vagus nerve (X)	

Spinal Accessory nerve (XI)	
Hypoglossal nerve (XII)	
<u>DORSAL SURFACE</u>	
4 th Ventricle	Part of ventricular system and CSF flow throughout CNS (covered in BB5)
Fasiculus gracilis and gracile tubercle	Fasiculus gracilis contains ascending sensory fibres in the dorsal column sensory pathway (covered in BB6)
Fasiculus cuneatus and cuneate tubercle	Fasiculus cuneatus contains ascending sensory fibres in the dorsal column sensory pathway (covered in BB6)
<u>AXIAL SECTION</u>	
4 th Ventricle	Part of ventricular system and CSF flow throughout CNS (covered in BB5)
Inferior olivary nucleus	Fibres project to cerebellum, involved in cerebellar pathways for control of movement
Nuclei of IX, X, XII	Origin of various functional components of these cranial nerves

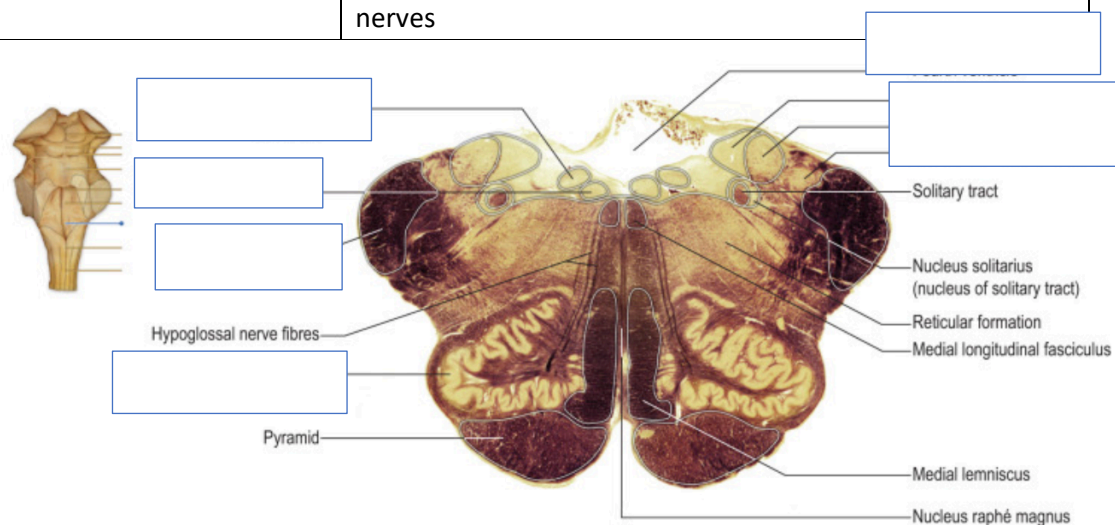


Fig. 9.7

Transverse section through the rostral medulla at the level of the inferior olivary nucleus.

What reflex can be used to assist in assessment of the function of the medulla? Describe the afferent and efferent limbs of this reflex and how it can be tested.

Apart from cranial nerve nuclei and sensory relay nuclei the medulla contains some important homeostatic centres. What are these nuclei concerned with?

STATION 2. CRANIAL NERVES IN CRANIAL BASE

You will already be familiar with the foramina of the cranial base which you studied during MM3. The foramina in the cranial base provide a pathway for the passage of cranial nerves and blood vessels as they exit and enter the skull.

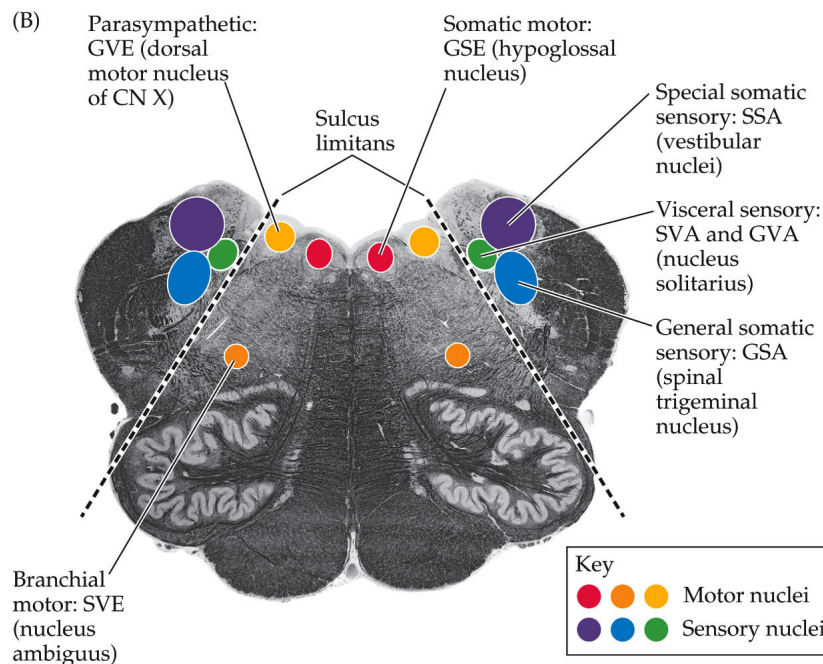
Review the cranial fossae on an image of the skull. Then locate the foramen of exit for each cranial nerve, including each branch of the trigeminal nerve. Record the foramina through which each nerve passes in the table below:

Cranial nerve	Name	Skull foramen
CNI	Olfactory	
CNII	Optic	
CNIII	Oculomotor	
CNIV	Trochlear	
CNV	Trigeminal	
CNV ₁	Trigeminal 1 st division- ophthalmic	
CNV ₂	Trigeminal 2 nd division- maxillary	
CNV ₃	Trigeminal 3 rd division- mandibular	
CNVI	Abducens	
CNVII	Facial	
CNVIII	Vestibulocochlear	
CNIX	Glossopharyngeal	
CNX	Vagus	
CNXI	Spinal accessory	
CNXII	Hypoglossal	

In which cranial fossa is the trigeminal ganglion located? What structures associated with the spinal cord is this ganglion homologous to? Why is it so large?

STATION 3. CRANIAL NERVE NUCLEI AND AUTONOMIC INNERVATION OF THE HEAD

Cranial nerves may contain several different types of nerve fibres - motor, sensory or both - each of which originate from different nuclei. Therefore a cranial nerve with multiple functions will have several nuclei within the brainstem. The arrangement of the nuclei in the brainstem is similar to those in the spinal cord. That is, sensory nuclei are located more dorsally, while motor nuclei are more ventrally located and the two groups are separated by the sulcus limitans.



NEUROANATOMY 2e, Figure 12.4 (Part 2)

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Which cranial nerves contain parasympathetic fibres? From which brainstem nuclei do these parasympathetic fibres arise?

Parasympathetic fibres synapse in ganglia located close to their target organs in the cranium.

Complete the table below to identify the parasympathetic ganglion in the head and the distribution of parasympathetic fibres for the three cranial nerves indicated:

Cranial nerve & Parasympathetic nucleus	Parasympathetic ganglion	Distribution of parasympathetic fibres
Oculomotor nerve; Edinger Westphal nucleus		
Facial nerve; Superior salivatory nucleus		
Glossopharyngeal nerve; Inferior salivatory nucleus		

Note: vagus nerve not included.

The vagus nerve is a mixed nerve, however the majority of its motor fibres are parasympathetic. What structures are innervated by parasympathetic fibres of the vagus nerve? Where do these presynaptic vagal fibres synapse?

The parasympathetic fibres that travel in the vagus nerve arise from the dorsal motor nucleus of X in the medulla. Where else are cell bodies of parasympathetic nerves located?

How do sympathetic fibres reach the structures they supply in the head? From where do they originate?

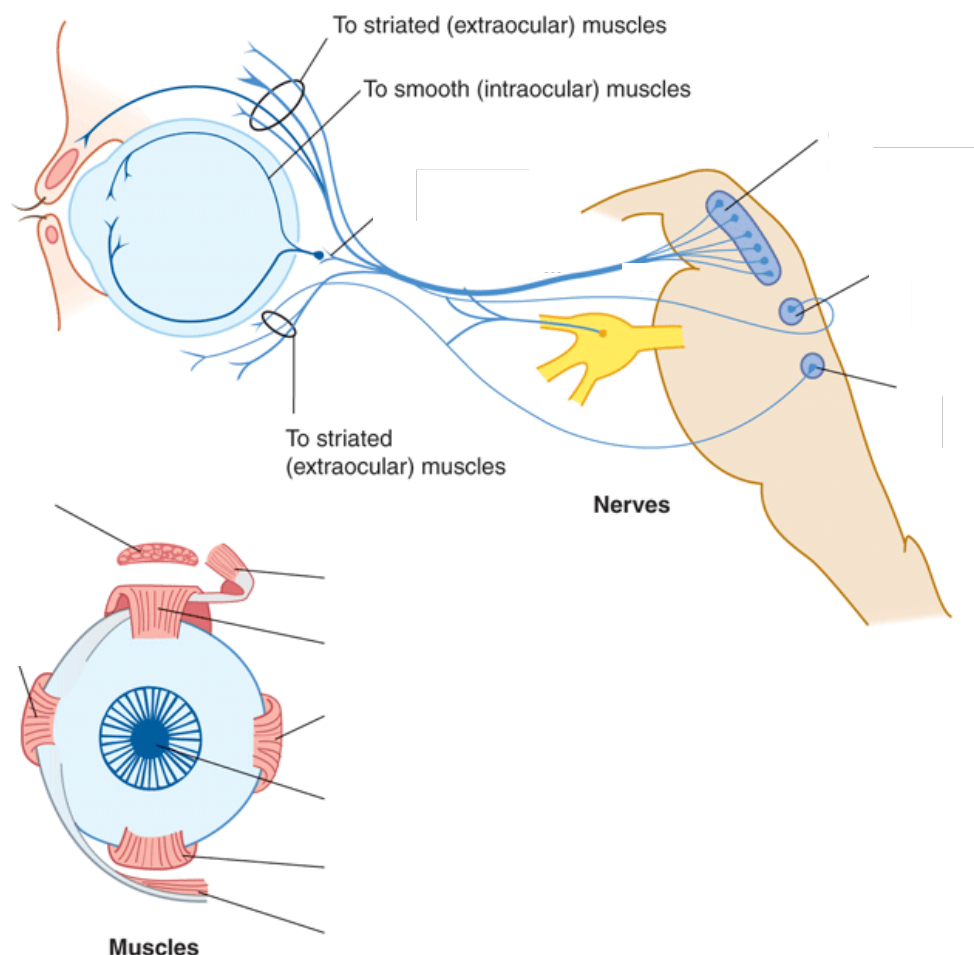
STATION 4. INNERVATION AND MOVEMENTS OF THE EYE

INNERVATION OF EXTRAOCULAR MUSCLES

Cranial nerves III, IV and VI control eye movements via the extraocular muscles. CNIII also controls pupillary constriction and eyelid opening. The Oculomotor nerve (III) arises from two overlapping nuclei, the Edinger-Westphal nucleus (parasympathetic fibres) and the oculomotor nucleus. The Trochlear nerve (IV) is the only crossed cranial nerve. Neurons arising in the trochlear nucleus cross within the midbrain and emerge contralaterally on the dorsal surface of the brain stem. The Abducens nerve (VI) nuclei are located within the pons. This nerve has a long course which makes it susceptible to injury at multiple points.

On the diagram below, identify the cranial nerves controlling eye movement, their associated nuclei and the extraocular muscles they innervate.

CRANIAL NERVE	BRAINSTEM NUCLEUS	OCULOMOTOR MUSCLES INNERVATED
Oculomotor nerve (III)		
Trochlear nerve (IV)		
Abducens nerve (VI)		



Examine the path of the trochlear nerve from the brainstem to the orbit.

How does the path of CNIV differ from other cranial nerves?

Which muscle does CN VI innervate? Why is an isolated palsy of this muscle notorious as a false localizing sign?

Consider the path of CN III from the brainstem to the orbit. How might a lesion of the oculomotor nerve present, and what important conditions must be considered if a patient presents with a new and painful third nerve palsy?

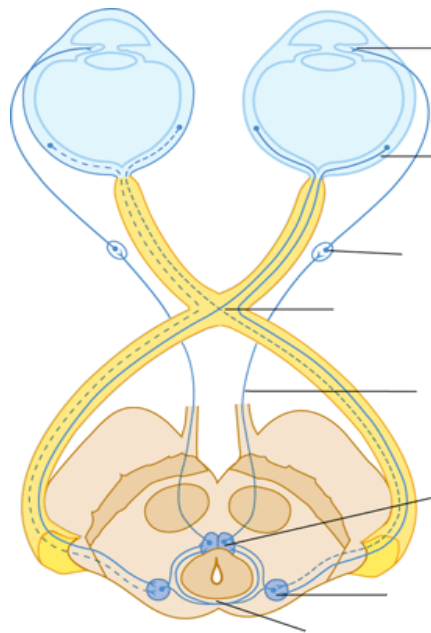
Use the images provided to determine which extraocular muscles are being assessed in the six positions of gaze. Identify which nerves are assessed in each position.

PUPILLARY LIGHT REFLEX

Light landing on the retina stimulates the afferent limb of this reflex pathway. Optic nerve fibres involved in this pathway synapse in the pretectal area of the midbrain. Signals are then sent bilaterally to the Edinger-Westphal (parasympathetic) nuclei of CNIII. Efferent fibres of CNIII then stimulate pupillary constriction in both eyes via constriction of the pupillary sphincter muscle. Due to the crossing of this pathway, both pupils normally constrict equally even if the light hits only one retina. This reflex can be used to assess the function of Cranial nerve II and III as well as the function of the midbrain where the synapses occur.

On the diagram below, label the following components of the pathway controlling the pupillary light reflex.

1. Afferent limb: optic nerve, optic chiasm, optic tract
2. Pretectal area
3. Edinger Westphal nucleus (parasympathetic fibres of III)
4. Efferent limb: Oculomotor nerve, ciliary ganglion, short ciliary nerves
5. Pupillary constrictor muscle



Source: Waxman SG: *Clinical Neuroanatomy, 25th Edition*;
<http://www.accessmedicine.com>
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Note the crossing of the pathway at the posterior commissure. What does this allow and how can this be observed?

When light is shone in one eye, constriction of the ipsilateral eye is termed a _____ response.

When light is shone in one eye, constriction of the contralateral eye is termed a _____ response.

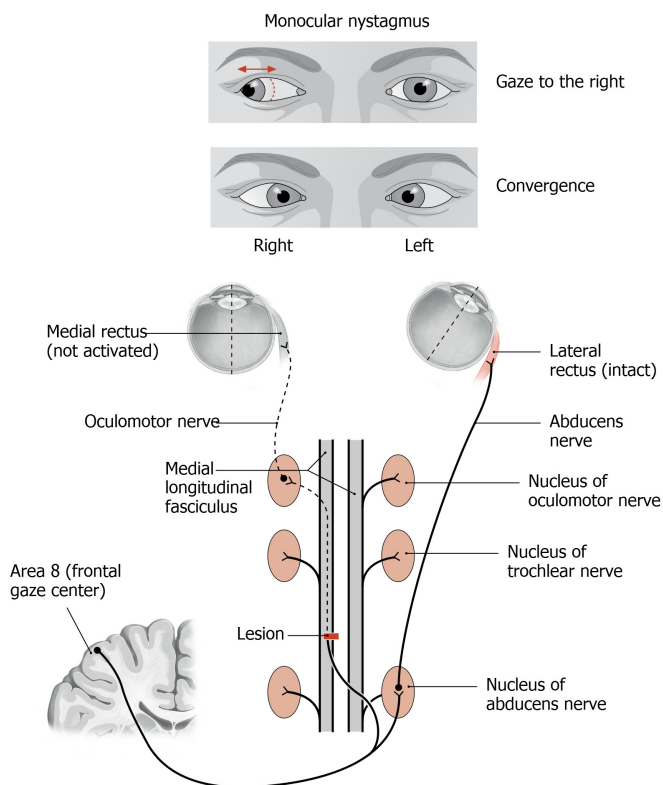
What response would be observed with a lesion of the optic nerve on one side?

What response would be observed with a unilateral lesion of the Edinger-Westphal nucleus?

Conjugate gaze

The concerted movements required for tracking an object and moving the eyes relative to the head and body require coordinated function of all of the cranial nerves controlling eye movement. These conjugate movements are controlled by supranuclear centres (premotor nuclei in the brainstem), and fibre tracts which connect the nuclei. Of particular clinical significance is the medial longitudinal fasciculus (MLF), which connects the cranial nerve nuclei concerned with eye movement with the vestibular nuclei (concerned with balance). It enables coordinated movement of the left and right eyes, in concert with the movements of the head and body. Lesions of this fasciculus result in a characteristic pattern of eye movement dysfunction known as internuclear ophthalmoplegia.

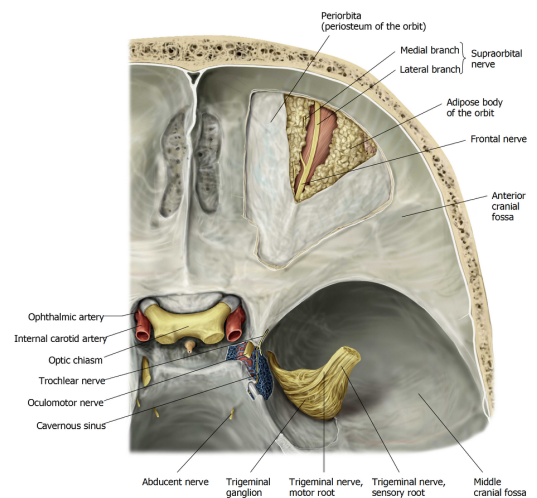
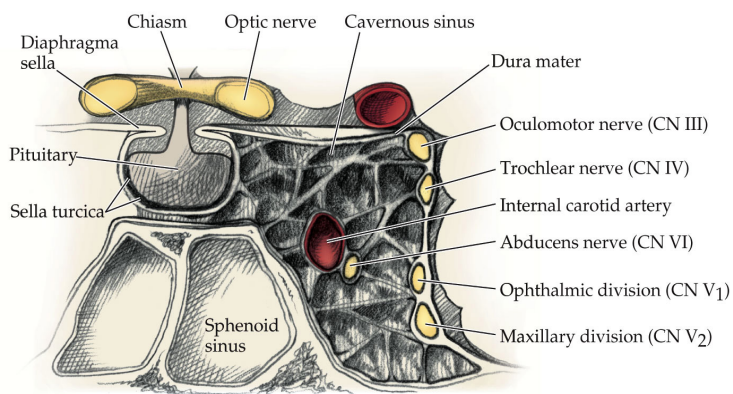
What pattern of eye movement is associated with internuclear ophthalmoplegia? What conditions may cause this condition?



STATION 5. CAVERNOUS SINUS LESIONS

Review your knowledge of the structures within and the relationships of the cavernous sinus. Identify the location of each of the following structures:

Olfactory nerve	Pituitary fossa
Optic nerve	Cavernous sinus
Optic tract	Internal carotid artery
Oculomotor nerve	Superior orbital fissure
Trochlear nerve	Ophthalmic nerve (V1)
Abducens nerve	



NEUROANATOMY 2e, Figure 13.11

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Schuenke, Atlas of Anatomy Vol. 3, 2nd Ed., Fig. 5.170 A, Illustrator: Karl Wesker/Markus Voll, ©2017 Thieme Medical Publishers, Inc. All Rights Reserved.

Neuroanatomy through clinical cases: Blumenfeld

How might a lesion within the cavernous sinus present? How would this compare to the symptoms of an orbital apex fracture?

STATION 6. TESTING CRANIAL NERVE FUNCTION

Having considered the various functions of the cranial nerves, it is important to know how to assess the function of these nerves. Linking the structures innervated with the assessment method will provide you with a good understanding of the purpose of the cranial nerve examination which will be covered in Clinical Practice during BB3.

Complete the following table to describe the best method for testing each of the cranial nerves

Cranial Nerve	Structures Innervated and their function	Method of testing
Olfactory -I	Olfactory epithelium in roof of nasal cavity – olfaction	
Optic - II		
Oculomotor - III	All extraocular muscles except superior oblique and lateral rectus - eye movements & lid elevation	
	Sphincter pupillae and ciliary muscles - constriction of pupil and accommodation	
Trochlear - IV	Superior oblique muscle – depression and intorsion of eye	
Trigeminal -V		Corneal reflex: patient looks up and away. • Touch cotton wool to other side. • Look for blink in both eyes, ask if can sense it. • Repeat other side [tests V1 afferent, VII efferent]. Facial sensation: sterile sharp item on forehead, cheek, jaw. • Repeat with dull object. Ask to report sharp or dull.

		• If abnormal, then temperature [heated/ water-cooled tuning fork], light touch [cotton].
	Muscles of mastication – jaw movements, tension on tympanic membrane	
Abducens - VI		
Facial - VII		
	Lacrimal glands, salivary glands except parotid – lacrimation and salivation	NA
		Test taste with sugar, salt or lemon juice on the lateral aspect of each side of the tongue.
	Sensation to small area of skin near the external auditory meatus	
Vestibulocochlear - VIII		
Glossopharyngeal - IX	Stylopharyngeus muscle - swallowing	NA
	Parotid gland – saliva production	NA
	Sensation to middle ear, pharynx, posterior tongue	

	Taste to posterior tongue 1/3, chemo and baroreceptors of carotid body & sinus	NA
Vagus - X	Motor to muscles of pharynx and larynx	<i>As for IX</i>
	<i>Visceral sensation & parasympathetic fibres to Heart, lungs, digestive tract</i>	NA
	<i>Sensation in Pharynx, meninges</i>	NA
	Taste to Epiglottis, chemo and baroreceptors in aortic arch	NA
<i>Spinal accessory- XI</i>		
<i>Hypoglossal XII</i>		

STATION 7. LOCALISING CRANIAL NERVE LESIONS:

Using your understanding of the function of the cranial nerves, examine the information provided in the cases and questions below to localise the lesions causing the presenting signs & symptoms:

CASE 1.

Betty is a 75 year-old pensioner who has been experiencing sudden attacks of extreme but short lived pain along her jaw. These are triggered by cold wind on her face, talking, chewing or brushing her teeth. She is losing weight because she is having difficulty eating and drinking. She is no better after visiting a dentist and having two teeth extracted. After one particularly bad day, she is admitted to hospital. The neurology registrar is asked to see her and finds that she has a normal neurological examination except that touching her lower face causes shooting pain.

Which cranial nerve is involved? What is the name of the condition? How could you further localise the problem?

Case 2.

Claire is a 30 year-old teacher who woke up with an unusually dry mouth and went to the bathroom to get a glass of water. As she raised the glass, she caught her reflection in the mirror and noticed that her face looked asymmetrical. When she took a gulp of water, some of it ran out of the left side of her mouth. She was alarmed and rang to ask for an urgent appointment to see her doctor. When she arrived, the entire left side of her face was droopy. The doctor did a careful cranial nerve examination and found that in addition to paralysis of the left side of her face, Claire had lost her sense of taste on the anterior 2/3 of the left side of her tongue. He diagnosed her as suffering from Bell's palsy.

What is the anatomic basis for Claire's dry mouth and loss of taste?

Explain the difference in paralysis of muscles of the face when the upper motor neuron controlling facial nerve is lesioned, compared to a lesion in the facial nerve after it exits from the pons.

Case 3.

John underwent surgery to remove a simple subcutaneous lump from the right side of his neck but now he is complaining of pain in his right shoulder and difficulty taking his T-shirt off. On your examination, he has a depressed right shoulder and is unable to abduct his right arm above shoulder level.

What do you suspect is the diagnosis? Trace the path of the nerve involved.

Case 4.

Jason is a 25 year-old man who has been admitted to hospital after being punched unconscious in a pub brawl. On initial examination, he had bilateral racoon eyes and a watery pink discharge from his right ear. Two days later, he complains of a persistent ringing in his ear. As you are talking to him, you notice that his right eye is slower to blink than his left and his right nasolabial fold is lost. Can you identify the cranial nerves involved and suggest the anatomical basis of the physical signs?

Scenario 5.

Horner's syndrome is caused by a lesion of the sympathetic fibres supplying the head. The syndrome is classically described as consisting of ipsilateral ptosis (drooping) of the eyelid, meiosis (constriction of the pupil), anhydrosis (lack of sweat) and enophthalmos.

Explain why each of these signs occur? What other cranial nerve lesion is a more common cause of ptosis?

Scenario 6.

Identify the cerebellopontine angle on a model or diagram. The most common tumour arising in this area is the acoustic neuroma, which arises around the internal auditory meatus.

Which nerve would you expect to be initially affected by this tumour, and how would it present? If such a tumour was allowed to grow, which other cranial nerves could be compromised?

Scenario 7.

What is the relationship of smell to taste? Can you explain the most common mechanism for post-traumatic aguesia (loss of taste), and where this may occur?

Loss of both vision and smell may result from lesions in which area?